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Blue Ribbon Task Force
Marine Life Protection Act Initiative
c/o 1416 Ninth Street
Sacramento, CA

Ocean Conservancy
Advocates for a Wild, Healthy Ocean

RE: Importance of Marine Reserves

Dear Chair Golding and Members of the Blue Ribbon Task Force:

We are writing on behalf of Ocean Conservancy to comment on issues relating to the design, evaluation and adoption of new marine protected areas (MPAs) for the North Central Coast region. As you know, over the next few months, the North Central Coast Regional Stakeholder Group will be refining MPA proposals that will be evaluated by the Science Advisory Team (SAT) and reviewed by your Task Force. As the North Central Coast process moves into analysis of specific MPA proposals, we urge that Blue Ribbon Task Force (BRTF) remain mindful of the unique and critical role of fully protected state marine reserves both in complying with the legal requirements of the MLPA and in meeting a wide range of ecological goals.

In summary, this letter addresses the following key points:

- The MLPA requires adoption of a core network of state marine reserves to protect all key marine habitats and associated biological communities.
- Empirical research documenting the conservation benefits of MPAs is largely based on studies of fully protected marine reserves.
- Scientific evidence demonstrates that partial-take areas do not provide the same conservation benefits as fully protected marine reserves and are more difficult to effectively administer, enforce and monitor.

We ask that you take this information into account as the MLPA Initiative moves forward.

The MLPA Requires A Core Network of State Marine Reserves.

The MLPA requires development of a comprehensive network of marine protected areas, anchored by fully protected state marine reserves representing all key habitats in replicate. Unlike traditional fisheries management regulations, the goals of the MLPA are directed at marine biodiversity, ecosystem function and restoration of marine life populations as well as providing improved opportunities for research, education and recreation.

Although the MLPA recognizes that a range of MPAs can contribute to the goals of the Act and thus allows use of partial take areas including both state marine conservation areas and state marine parks, the law explicitly requires adoption of an "improved marine reserve component" (FGC Section 2853 (c) (1)) and describes marine reserves as "an essential element of an MPA system." (FGC Section 2851 (f)) Thus, in adopting the MLPA, the California Legislature recognized the unique value of fully protected state marine reserves, mandating that this highest level of protection be the backbone of California's new system of MPAs.

The MPA network your recommended for the South Central Coast included a mix of MPAs including state marine reserves, state marine parks, and state marine conservation areas representing a range of sizes, habitats types and levels of protection. The adopted South Central Coast MPA network was anchored by a core network of inshore state marine reserves designed to meet the SAT minimum size guidelines (nine square miles) coupled with offshore high protection state marine conservation areas that brought these core MPA clusters to the SAT's preferred size range of no less than 18 square miles.

We urge that the BRTF take a similar approach in the North Central Coast region – emphasizing state marine reserves that protect all key habitats, coupled with use of high protection marine conservation areas in deeper water areas - to ensure that the final network complies with the intent of the MLPA. Such an approach will also help ensure the consistency between regions necessary to result in a cohesive statewide network of MPAs.

Empirical Evidence of MPA Effectiveness is Largely Based on Marine Reserves.

Most of the research that has been published regarding the impacts of MPAs has been based on studies related to fully protected marine reserves. For example, the National Research Council (2001) Report on MPAs includes a chapter documenting a variety of conservation benefits associated with MPAs including increases in abundance, body size, biomass, diversity, and reproductive capacity within MPA areas. Virtually all of the studies referenced in this chapter of the NRC Report are based on studies in no-take marine reserves. Similarly, Halpern's 2003 review of 89 existing published studies on the effects of marine reserves is limited to no-take areas.

Given that most of the scientific research that has been published related to the benefits of MPAs was performed on no-take marine reserves, use of fully protected areas are more likely to result in such benefits on the California coast. Allowances for take within MPAs are likely to reduce the conservation benefits of the MPAs and the over all effectiveness of the MPA network. Although partial take areas can play a valuable role under the MLPA, they should be viewed as a complement to fully protected areas and not as a substitute for a core network of marine reserves.

Partial Take MPAs Do Not Provide the Benefits of Fully Protected Reserves.

Although most of the published research related to MPAs is based on study of no-take marine reserves, the data available comparing no-take areas with those allowing limited take suggests that allowing some level of extraction can reduce or even eliminate the benefits associated with the MPA. Problems with allowing partial take can result from direct or indirect ecological effects as well as difficulties in administering and enforcing areas with complex or confusing regulations.

Sobel and Dahlgren (2004) note that allowing some fishing in an area can open up both enforcement and ecological difficulties. They warn that allowing some fishing in an MPA threatens the protected area with ecological effects that may cascade through the ecosystem and caution that since we know relatively little about many ecological interactions, any allowance for fishing may have unforeseen consequences.[1]

Denny and Babcock's (2004) study of a New Zealand marine park closed to all commercial fishing but open to recreational fishing (by unweighted single hook lines, trolling or spearfishing) found that when compared to a fully protected marine reserve and to open areas, the marine park most closely resembled the areas that were fished. Notably, the fish allowed to be caught were all thought to be nomadic or pelagic and not considered to be part of the resident demersal reef fish assemblage the park was designed to protect. At the time, there was limited information on the biology and ecology of three species that were later found to be reef residents and therefore very vulnerable to fishing.[2]

Similarly, Schroeder and Love's (2002) study of California rockfish assemblages for three differently fished areas: open to all fishing, open only to recreational fishing, and a de facto reserve, demonstrated the impacts of recreational angling within an MPA. The area open to recreational fishing had the lowest rockfish density with predominantly small fishes, leading the authors to conclude that large predators may disappear when a reef is fished even lightly, and this in turn may alter ecosystem structure through top-down, trophic cascades. [3]

Finally, partial take MPAs can create a host of management challenges that can increase the administrative burdens and undermine the effectiveness of an MPA network. Bohnsack et al. (2004) provide 17 reasons why there is strong scientific, management, and public interest in using no-take marine reserves versus multiple-use or zoning.[4] He notes for example that only no-take reserves

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[1] Jack Sobel and Craig Dahlgren. 2004. Marine Reserves A Guide to Science, Design, and Use. Island Press, Washington, DC. Page 154-156.
[2] Denny, C.M., and R.C. Babcock. 2004. Do partial marine reserves protect reef fish assemblages? Biological Conservation 116:119-129.
[3] Schroeder, D.M. and M.S. Love. 2002. Recreational fishing and marine fish populations in California. CalCOFI Rep. 43: Pages 182-190.
[4] Bohnsack, J.A. et al. 2004. Why have no-take marine protected areas? American Fisheries Society Symposium 42:183-193.

can effectively serve as control sites to evaluate the impacts of fishing on marine ecosystems and to distinguish between natural and human –caused disturbance. An MPA system built largely on partial-take MPAs would not provide adequate control sites. Furthermore, monitoring such a system would be impractical since it would be very difficult to eliminate the confounding effects of fishing from other impacts. Use of marine reserves can also simplify enforcement. Since fishing in an area is by definition a violation, wardens do not have to board a vessel to determine the size or species caught or verify gear type being used. However, a complex system of MPAs each with its own set of regulations would be very difficult for the public to understand and likely lead to poor compliance.

Conclusion

Included in the legislative findings of the MLPA is a conclusion that California's pre-MLPA array of MPAs: "creates the illusion of protection while falling far short of its potential to protect and conserve living marine life and habitat." FGC Section 2851 (a). We urge the BRTF to read this finding as a caution about the serious risks posed by adopting a network made up of MPAs that do not provide meaningful ecological protection. We urge you to ensure that the North Central Coast MPA network include a core of fully protected marine reserves and be aware of the complications and limitations of partial take MPAs, particularly those with low levels of protection.

Thank you for your consideration of these comments.

Sincerely,

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American Fisheries Society Symposium 42:185–193, 2004

Why Have No-Take Marine Protected Areas?

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Abstract.—Although the title of this symposium implied a focus on fully protected marine areas, most presentations actually dealt with a range of traditional "marine protected areas" or "marine managed areas" that offer less than "full" resource protection. Some presentations noted a backlash against establishing no-take reserves. Here we provide 17 reasons why there is a strong scientific, management, and public interest in using no-take marine reserves to build sustainable fisheries and protect marine ecosystems. We also discuss some underlying technical and philosophical issues involved in the opposition to their usage.

Introduction

Marine protected areas are used increasingly to manage marine resources, but they often mean different things to different people, based primarily on the level of protection they provide. The World Conservation Union defined marine protected areas (MPAs) as "any area of the intertidal or subtidal terrain, together with its overlying water and associated flora, fauna, historical and cultural features, which has been reserved by law or other effective means to protect part or all of the enclosed environment" (IUCN 1994; Kelleher 1999). In the USA, Presidential Executive Order 13158 provided a similar definition: "any area of the marine environment that has been reserved by Federal, State, territorial, tribal or local laws or regulations to provide lasting protection for part or all of the natural and cultural resources therein." Under these broad definitions, a wide variety of sites could be considered as MPAs.

We focus on "marine reserves," here defined as marine protected areas permanently closed to all fishing and other extractive uses with limited exceptions for research and education by permit (Ballantine 1997). Because of the many different terms that have been used to describe marine reserves, the terminology is often confusing to both scientists and the public. Common terms used to describe marine reserves include no-take areas, nonconsumptive areas, fishery reserves (PDT 1990), marine ecological reserves, sanctuary preservation areas (USDOC 1996), research natural areas (Brock and Culhane 2004, this volume), fully protected areas (Roberts and Hawkins 2000), and sanctuary, outside the USA.

Closing areas to fishing has long been widely practiced in fishery management in historical and modern times to protect critical habitat, restore depleted species, and protect vulnerable stocks at spawning aggregation sites (e.g., Beverton and Holt 1957). Most closures, however, have been either seasonal, applied only to specific species, or have been limited to restrict certain destructive or wasteful fishing methods. Rarely have areas been permanently closed to all types of fishing. Modern fisheries interest in marine reserves began in the 1980s as a way to both protect marine ecosystem biodiversity and build sustainable fisheries (PDT 1990; Bohnsack 1996; Bohnsack and Ault

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(3) Precautionary Approach
The precautionary approach can be stated simply: when in doubt, be cautious. In practice, if you don't have a complete understanding about the functioning and dynamics of natural systems or their management, then some resources should be withheld from exploitation until a complete understanding is obtained (Bohnsack 1999a). Lauck et al. (1998) demonstrated how marine reserves can mitigate the effects of uncertainty associated with fishery exploitation.

(4) Shifted Burden of Proof
Compared to other types of managed areas, marine reserves shift the burden of proof from proving that fishing causes an adverse impact to proving that it does not (Dayton 1998). The result is that, in reserves, management focus shifts from a risk-prone approach, in which actions are taken only after resource impacts are demonstrated, to a more risk-averse approach, in which resources are protected until it can be demonstrated that an activity is not harmful.

(5) Existence and Future Value
Marine reserves help protect existence value for people who do not directly use resources and for future generations. Aldo Leopold (1949) noted that we cannot prevent the alteration, management, and use of resources, but we need to affirm their right to continued existence, and in some places, their continued existence in a natural state. His biotic ethic requires human obligation, responsibility, and self-sacrifice to preserve ecosystems for present and future generations. This mantra needs to be adopted for effective management of marine ecosystems.

(6) Increased Public Understanding and Appreciation
Marine reserves provide opportunities for quality formal education at the primary, secondary, and graduate levels. With public access, they also provide better public understanding and appreciation of marine ecosystems and marine reserves and the importance of effective resource management. Pauly (1995) described the shifting baseline problem in which each generation develops lower expectations about natural resources based on its own direct experience with depleted resources. Marine reserves with public access offer an opportunity to reverse this trend by restoring areas with more natural and healthy ecosystems. They also provide citizens an opportunity to directly observe the effectiveness of resource management and understand its importance by comparing reserves to surrounding areas.

(7) Enhanced Nonextractive Human Uses
By separating incompatible activities and protecting some areas from fishing and depletion, no-take reserves can support nonextractive uses that have ecological, social, genetic, economic, educational, scientific, recreational, aesthetic, spiritual, and wilderness importance (Bohnsack 1998). They can diversify the economy by providing new social and economic opportunities. This is especially important for activities that require high resource quality. Otherwise, only those activities that depend on depleted or low quality resources can persist.

(8) Better Resource Protection
Unlike many other measures, there are no legal ways to avoid or circumvent the no-take provision which offers the possibility of better overall resource protection than do other measures. Trip limits and bag limits for a recreational fishery, for example, are popular conservation measures, but their effectiveness can be circumvented by making more fishing trips. Similarly, the effectiveness of gear restrictions and minimum size limits can be negated by increased fishing effort. Marine reserves also offer better resource protection because they buffer against changes in total effort or fishing practices in surrounding areas.

Scientific Considerations

(9) Objective Criterion
The no-extraction criterion prohibiting any activity that intentionally removes organisms or habitat is objective and easy to determine as compared to many other criteria that are subjective or difficult to define. Allowing "limited extraction" in a multiple-use MPA, for example, is problematic because there is no clear definition of what "limited" means. Accurately determining a level of extraction that is "not harmful" to a population or an ecosystem is difficult and mostly unknown. Also, monitoring or controlling the amount of take is not practical in most cases.

(10) Simplicity
Compared to other criteria, it is easy to determine whether an activity is extractive or not and fundamentally simpler to explain than why some users are allowed to remove resources and not others. Note, nonextractive, is not the same as, nor should it be confused with, nonconsumptive. Nonextractive recreational diving, for example, could be considered consumptive as the result of repeated contact and damage to the benthos. Allowing diving and other

make monitoring and enforcement of marine reserves more practical.

(16) Direct Fishery Benefits

Marine reserves potentially can provide many direct fishery benefits (Bohnsack 1998). The five most important benefits follow. Reserves can reduce the chances of overfishing by providing refuges from population exploitation. Compared to having all areas exploited under one set of regulations, reserves potentially can provide greater fishery yields in the long-term by having a larger and more dependable supply of eggs and larvae dispersed to fishing grounds. Reserves can also potentially increase yield from spillover, where animal emigration exports biomass from reserves through to surrounding fishing grounds (PDT 1990; Roberts et al. 2001). Reserves also can provide insurance to sustainable stocks by potentially accelerating stock recovery following natural disturbance, human accidents, management errors, or years of poor stock–recruitment (PDT 1990). Finally, they may be the only measure that can effectively preserve stock genetic structure from detrimental effects of selective fishing practices (Conover and Munch 2002).

(17) Indirect Fishery Benefits

Fishery stock assessment and management models depend on obtaining accurate estimates of critical population parameters of growth, natural mortality, and fecundity. If all areas are subjected to fishing, measuring these parameters and gaining an essential understanding of trophic and habitat relationships, recruitment variations, behavior, and population response to environmental variability are difficult, if not impossible, to obtain. Marine reserves can potentially benefit fisheries indirectly by allowing some critical population dynamic and fishery parameters to be estimated independent of fishery influences with a rigorous sampling design (Ault et al. 2002).

Discussion and Conclusions

The main priority of permanent no-take marine reserves is to protect biodiversity: ecological structure and function at the genetic, species, community, seascape, and ecosystems levels (NRC 2001). Their use has generated considerable scientific, management, and public interest because the no-extraction provision is simple and objective and offers a high level of resource protection that can potentially restore and maintain ecological integrity in areas with minimum human disturbance. Many scientific questions can best or only be examined using marine reserves. From a management perspective, marine reserves are attractive because they potentially provide a win–win conservation alternative that offers a high level of ecosystem protection while providing fishery benefits and enhancing and diversifying nonextractive human uses.

Much, however, remains to be learned because the science of marine reserves is new and most existing reserves are rare, small, recently established, limited to few habitats, or cover only very small portions of the total managed area (Pauly 2004, this volume). Because they are rare, more need to be implemented if they are to provide anything more than a token role in protecting marine biodiversity. Because marine reserves are rare and recently established, few scientific studies exist (Halpern and Warner 2002; Halpern 2003), leaving many questions and uncertainty concerning their application to biodiversity and fishery protection. More research is needed to address questions concerning individual reserve size, total number, location, total area, and habitats that need to be included to be truly effective. In addition, more replicated research is needed, especially at larger and more ecologically relevant spatial and temporal scales, to address questions of costs and benefits, effectiveness, and necessary design features for reserve networks. Many questions remain unresolved concerning social and ecological impacts of fishing displacement, applications to highly migratory species, and social acceptance, compliance, and enforcement. Thus, considerable scientific interest exists in establishing reserves in different regions and habitats and under different biological, oceanographic, and physical environments as well as in different social and economic environments.

Even though they prohibit fishing, marine reserves do not conflict with "multiple-use MPAs" because they create or enhance many kinds of activities within and outside their boundaries that conflict with fishing. When embedded in larger MPAs such as the Florida Keys National Marine Sanctuary, for example, they also support multiple human uses by separating incompatible activities and increasing total resource protection. A belief that fishing and other human activities can be practiced simultaneously in all areas without conflict is becoming far less realistic considering growing human population demands and the intensity of resource usage. Likewise, allowing all areas to be exploited with "limited restrictions" demands a high level of knowledge and human control that at present is essentially nonexistent.

failure of marine reserves per se but a failure to include marine reserves as part of comprehensive resource management strategies. Despite claims by some opponents, we know of no statements that marine reserves alone will solve all fishery problems. If overfishing is a problem, effort controls and other traditional fishery measures are also needed, including size limits, bag limits, quotas, limited entry, closed seasons, gear restrictions, and closed areas for specific fisheries (Bohnsack 2000b). If these other fishery measures are not effective, larger proportions of habitats may need to be closed. Relying solely on no-take protection, however, may reduce options and flexibility for optimizing social and economic benefits (Murray et al. 1999).

Third, use of marine reserves represents a philosophical shift from single-species and reactive fishery management to a more precautionary approach using proactive spatial and ecosystem-based management (Bohnsack 1999b). Although many practical details still need to be worked out to make this shift operational, at the theoretical level it requires integrating fishery and ecosystem considerations.

In conclusion, no-take marine reserves are primarily intended to protect ecosystem biodiversity. They offer qualitative and quantitative qualities that are more than simply sequestering populations in no-take areas (Norse et al. 2003) or providing just another fishery management tool (Norse et al. 2003). Fundamentally, marine reserves use a simple, ecosystem-based, and precautionary approach to offer a high level of resource protection that benefits present human activities and future generations. Marine reserves increase human knowledge, understanding, and appreciation of marine ecosystems and their management by offering a high and objective level of protection and a scientific basis for assessing human impacts and management effectiveness. Reserves potentially can simplify enforcement, benefit fisheries, and eventually achieve wide public acceptance. We suggest that advancing the science of resource management requires considering people a fundamental part of marine ecosystems, shifting the focus of fishery management from resources as mere commodities to sustaining functional ecosystems, and incorporating marine reserve concepts and networks into comprehensive marine resource management.

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RECREATIONAL FISHING AND MARINE FISH POPULATIONS IN CALIFORNIA

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ABSTRACT

We present and review information regarding recreational angling and exploited marine fish populations in California. A comparison of rockfish assemblages among three differently fished areas (one open to all fishing, another open only to recreational fishing, and a de facto marine protected area) revealed large differences in fish density, size structure, and species composition. The area open to all fishing harbored the highest density of rockfishes (7,212 fish/ha), although the size structure and species composition were dominated by small fishes. The area open only to recreational fishing had the lowest rockfish density (423 fish/ha) and a size structure also dominated by small fishes. The de facto protected area possessed high fish density (5,635 fish/ha), but here the size structure and species composition shifted toward larger fishes compared with the two fished areas. Two species federally listed as overfished, cowcod and bocaccio, had 32-fold and 408-fold higher densities, respectively, in the de facto reserve than observed inside the recreational fishing area, and 8-fold and 18-fold higher densities, respectively, than observed in the area open to all fishing. For 17 nearshore fish species, we compared landings by recreational anglers and commercial harvesters and found that, for 16 species, recreational angling was the primary source of fishing mortality. We illustrate the potential damaging effects of mortality associated with catch-and-release programs on long-lived fish populations. Based on this information, we recommend that legislators and natural resource managers reject the assumption that recreational fishing is a low or no impact activity until specific studies can demonstrate otherwise.

INTRODUCTION

The history of fisheries management on the West Coast of the United States records a steady allocation battle between recreational and commercial fishers (e.g., Clark and Croker 1933). This battle recently intensified with the formation of federal and state policies giving marine protected areas (MPAs) a leading role in managing and rebuilding fisheries. Since the extent of protection provided by MPAs varies greatly and often generates semantic confusion, we use the term MPA in this report to mean areas of "no take," that is, where all extraction activities are prohibited. One response to the increasing popularity of federal and state MPA policies is the proposed Freedom to Fish Act. This act would critically modify the Magnuson-Stevens Fishery Conservation and Management Act by allowing areas to be closed to recreational fishing only when there is clear demonstration that recreational anglers contribute to overfishing and all other management options, such as seasonal closures and bag and size limits, have been exhausted. Implicit in this type of legislation are the assumptions that overfishing is caused primarily by commercial harvesting and that recreational fishing does not interfere with other common goals of spatial closures, including (1) creating sustainable fisheries, (2) protecting essential fish habitat, (3) protecting marine ecosystem structure (biodiversity, trophic structure), (4) establishing scientific control areas necessary to distinguish between changes in marine populations caused by anthropogenic or natural sources, (5) creating marine wilderness areas, and (6) enhancing enjoyment of non-consumptive activities, including educational activities. A null hypothesis of no impact to marine populations and habitats from recreational fishing places a logistical and legal hardship on resource managers and consequently must undergo careful examination before any agency endorsement.

The dynamics of fish populations and fisheries are complex, and predicting the dynamics of complex systems usually contains a measure of scientific uncertainty. Fisheries management decisions must therefore allocate risk, with allocations often reflecting various social values (Ludwig et al. 1993). By seeking to maximize fishery yields, traditional fisheries management places most of this risk burden onto fish populations (Dayton 1998). Such a tendency has been injudicious because (1) fisheries can be overexploited before managers and scientists have sufficient data to indisputably document declining population trends, and (2) overexploited fisheries rarely recover after collapse (Hutchings 2000). In contrast to the history of commercial fisheries, there is little information on the need for management or its effectiveness in recreational fisheries. Thus, it is unclear

TABLE 1
Mean Number of Rockfish per Hectare (+1 SE) at Three Sites in the Southern California Bight

	Commercial and recreational fishing area	Recreational fishing only area	De facto marine protected area
All rockfishes	7,212 (1,300)	423 (69)	5,635 (1,908)
Cowcod	12 (3)	3 (7)	96 (43)
Bocaccio	70 (15)	3 (7)	1,225 (231)

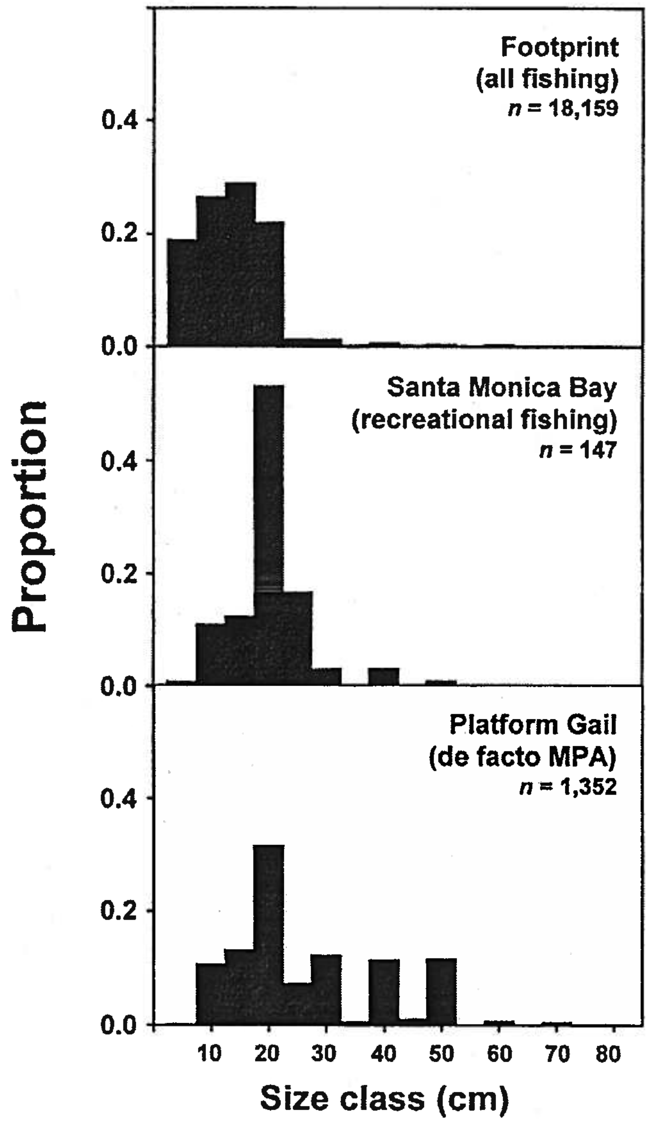

Figure 2. Size structure (total lengths) of all rockfishes observed among three differently fished areas.

open only to recreational fishing, we analyzed transects performed in Santa Monica Bay at depths of 100–300 m from fish surveys conducted in 1997 and 1998. Reef areas surveyed in Santa Monica Bay consisted of high rocky relief and are popular fishing spots with private boat owners and the commercial passenger fishing vessel (CPFV) fleet. At the time of our fish surveys, no deep reef habitat off California had been officially designated as an MPA. However, the offshore oil platforms in the Southern California Bight form de facto reserves. Benthic fishing effort near offshore platforms is very low because platform operators discourage marine vessels from entering a 150 m radius buffer zone around oil platforms. In addition, platform architecture and typically strong offshore currents hamper successful deployment and retrieval of fishing gear to the seafloor adjacent to the structure. As the de facto MPA, we quantified rockfish density only around the base of Platform Gail, which is situated in a depth of 230 m. Other offshore oil platforms in the eastern Santa Barbara Channel are not located at depths suitable for adult cowcod and bocaccio rockfishes. We conducted fish surveys around Platform Gail during 1995, 1996, 1997, 1999, and 2000. Mean rockfish densities from transects surveyed at each area were standardized to number of fish per hectare.

The density of all rockfish species combined was highest at the Footprint, which is open to all types of fishing (tab. 1). Species composition was dominated (67%) by dwarf varieties, such as squarespot (*S. hopkinsi*), swordspine (*S. ensifer*), and pygmy (*S. wilsoni*) rockfishes. The size structure of rockfish total lengths at the Footprint reflects this dominance of small species (fig. 2). In Santa Monica Bay, the density of all rockfish species was an order of magnitude less than rockfish density at the Footprint (tab. 1). Size structure was similar between the two fished areas in that the distribution is sharply truncated at sizes greater than 20 cm (fig. 2). Sixty-three percent of fish observed in Santa Monica Bay belonged to the subgenus *Sebastomus*. At Platform Gail, rockfish densities were also high (tab. 1), but the size structure here was skewed toward a greater proportion of large rockfish (fig. 2). The most commonly observed taxa at Platform Gail were the greenspotted/greenblotched species complex (*S. chlorostictus* and *S. rosenblatti*), which formed 41% of the assemblage.

Striking differences in density were found in cowcod and bocaccio densities among the three areas surveyed. Cowcod densities at Platform Gail, the de facto reserve, were 32 times greater than densities observed at Santa Monica Bay, the area open only to recreational fishing, and nearly 8 times greater than densities at the Footprint, the area open to all fishing (tab. 1). Bocaccio densities observed at Platform Gail were an extraordinary 408-fold greater than Santa Monica Bay estimates, and an 18-fold greater density than Footprint estimates (tab. 1). Composition was also quite different among the three areas: bocaccio constitute 22% of the total number of fish at Platform Gail, compared with 0.7% and 1% at Santa Monica Bay and the Footprint, respectively.

TABLE 2
Fish Species in California's Nearshore Fishery

Common name	Scientific name
Monkeyface prickleback	*Cebidichthys violaceus*
Kelp greenling	*Hexagrammos decagrammus*
Rock greenling	*Hexagrammos lagocephalus*
California scorpionfish	*Scorpaena guttata*
Cabezon	*Scorpaenichthys marmoratus*
Kelp rockfish	*Sebastes atrovirens*
Brown rockfish	*Sebastes auriculatus*
Gopher rockfish	*Sebastes carnatus*
Copper rockfish	*Sebastes caurinus*
Black-and-yellow rockfish	*Sebastes chrysomelas*
Calico rockfish	*Sebastes dallii*
Quillback rockfish	*Sebastes maliger*
Black rockfish	*Sebastes melanops*
Blue rockfish	*Sebastes mystinus*
China rockfish	*Sebastes nebulosus*
Grass rockfish	*Sebastes rastrelliger*
Olive rockfish	*Sebastes serranoides*
Treefish	*Sebastes serriceps*
California sheephead	*Semicossyphus pulcher*

based on the Pacific Fisheries Information Network (PacFIN) database, also maintained by the Pacific States Fishery Management Council. This database collates information on commercial landing receipts, vessel registration, and permit information, and is supplemented by data sources that supply species composition and catch-by-area proportions developed from port sampling and trawl logbook data systems.

Suspension of the Marine Recreational Fisheries Statistics Program occurred during 1990 to 1992. This three-year data gap coincides with the development of the commercial live/premium finfish market, which began conspicuous participation in the nearshore fishery in the early 1990s. We summarize data within two time periods 1980–89 (hereafter "the 1980s"), and 1993 to 2000 (hereafter "the 1990s"), to reflect this development.

Total landings of 17 nearshore species decreased considerably over the time frame examined. Mean total landings during the 1990s were 42% less than mean total landings during the 1980s. The decline observed in the 1980s, before the establishment of a large live/premium finfish market, was much steeper than the decline observed in the 1990s (fig. 3a), although the 1990s decline may have been somewhat stemmed by stricter total-allowable-catch regulations in 1999. A change in the relative catch between recreational anglers and commercial harvesters occurred with the advent of the live/premium finfish market. During the 1980s, recreational anglers caught about 87% of the total landings, but this decreased to 60% of total landings in the 1990s. However, recreational catch still exceeded commercial catch in all years (fig. 3b).

Greater variability in patterns of exploitation among user groups emerged when species were examined sep-

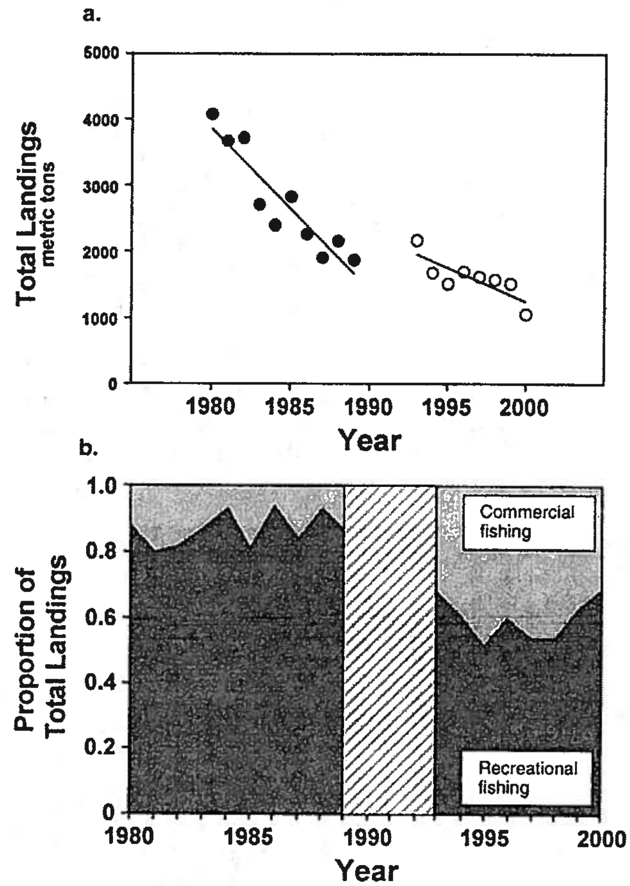

Figure 3. Annual landings in the nearshore fishery off California. No recreational data were collected in 1990–92. (*a*) Total landings, summing both recreational and commercial catches. Straight lines for each data set were calculated using the least squares method. (*b*) Proportion of total landings caught in each year by recreational or commercial fishers.

arately. The 1990s recorded an increase in relative commercial landings in all species, with the largest shifts occurring in seven species: California sheephead, cabezon, and grass, quillback, black and yellow, china, and copper rockfishes (fig. 4). At the other end of the spectrum, recreational anglers landed 75% or more of the total catch in seven species: California scorpionfish, kelp greenling, treefish, and calico, blue, olive, and kelp rockfishes (fig. 4).

In light of these data trends, one can easily understand the alarm of recreational anglers about the nearshore environment. A steep decline in landings combined with an increasing proportion of the catch going toward commercial harvesters is such that in the 1990s, the average recreational angler in California caught 65% less in the nearshore than what he or she might have caught in the 1980s. Nevertheless, it remains clear that in the aggregate, recreational fishers impacted nearshore populations more than commercial harvesters.

Recreational anglers dominate other fisheries that show signs of depletion. Karpov et al. (1995) report that

We now consider the effects CR mortality may have on protected fish populations by examining a case study of giant sea bass (*Stereolepis gigas*). An area along the north shore of Anacapa Island has recently been designated as a no-take MPA, in part due to numbers of giant sea bass frequently observed there. These fish attract recreational (nonspearfishing) scuba divers and play an increasingly important role in the education and outreach program at the Channel Islands National Marine Sanctuary (K. deWet-Oleson, pers. comm.). The take of giant sea bass has been prohibited in recreational and commercial fishing since 1981, after the species had already plummeted to catastrophically low levels (Crooke 1992). Giant sea bass live to at least 75 years and probably longer (Love 1996). They are the largest reef fish in California, and adults feed on a variety of fishes, decapod crustaceans, and cephalopods. Numerous videos taken by recreational divers suggest that most giant sea bass observed near Anacapa Island are from one successful year class that recruited during the 1983–84 ENSO event.

The effect of a small increase in mortality rate on population dynamics may be difficult to visualize because such rates are compounded through time, causing populations to decline in an exponential manner rather than in a linear one. This means that very small CR rates may have considerable impact on long-lived fish populations. Ironically, a fishing public that does not differentiate between a 6% and 7% annual mortality rate may immediately recognize the considerable difference between a 6% and a 7% annual interest rate on a 30-year mortgage, even though both examples compound rates through time. We therefore choose to use graphical methods to demonstrate the potential consequences of CR mortality to giant sea bass under five different demographic regimes: natural mortality only, and natural mortality plus one of four CR mortality rates (1%, 5%, 10%, or 20%). There are no estimates of natural mortality in giant sea bass, so we used Hoening's (1983) regression formula, which predicts annual mortality rate, m, on the basis of maximum age, t_{max}, by the formula $ln\ (m) = a + b\ ln\ (t_{max})$, where $a = 1.44$ and $b = -0.982$. A maximum age of 75 years translates into an annual mortality rate of 6%. We also lack information on CR mortality rates of this species, although a scientific tagging study on these fish around Anacapa Island recorded one fatality among six tagged individuals in 2000 (S. Fangman, pers. comm.). Given the low numbers of giant sea bass, their aggressive nature, the close proximity of Anacapa Island to several major harbors, and the large number of fishers present in the northern California Channel Islands, it is reasonable to assume that each giant sea bass at Anacapa Island is hooked once per year. This assumption allows the CR mortality rate and the natural mortality rate to be on the same temporal scale.

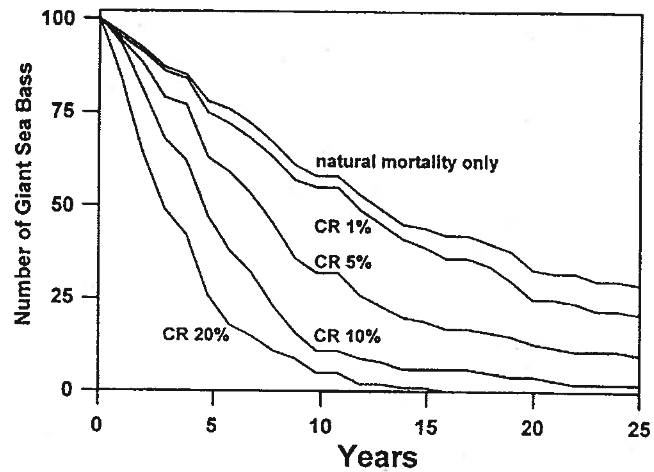

Figure 5. Population trajectories of giant sea bass (*Stereolepis gigas*) under five different mortality regimes: natural mortality only, and natural mortality plus one of four catch-and-release (CR) mortality rates.

We projected population abundance through time by exposing each giant sea bass in the model population to independent mortality risks at each yearly time step. The population projection lasted 25 years, during which time we assume no immigration of individuals (juvenile or adult) from other areas. The baseline population began with 100 fish that endured only the estimated natural mortality rate; that is, at each time step, each fish had a 6% chance of dying from natural causes. The baseline population trajectory was then exposed to varying rates of additional mortality (1–20%) to delineate changes in population dynamics that may be associated with a catch-and-release program for this species.

After 25 years, 29 giant sea bass remained alive in the baseline population; the addition of any CR mortality changes this number considerably (fig. 5). A 20% CR mortality rate causes extinction of the giant sea bass population after 16 years. A 10% CR mortality rate leaves two fish remaining at the end of the time period considered, and a 5% CR mortality rate leaves 10 fish. A CR rate of only 1% reduces the baseline population by 28%, down to 21 fish (fig. 5). It may be that in southern California, juvenile recruitment of giant sea bass is only significant during strong ENSO events. Consequently, without steady juvenile recruitment events, a small amount of CR mortality added to giant sea bass population dynamics may perilously delay population recovery or even cause local extinction.

The sea bass example presented here is one possible scenario; other fish species may tolerate a CR program quite successfully. Important variables likely to affect tolerance to a CR program include mean fish life span, degree of density dependence in demographic rates, and the rate at which individuals within a population experience a CR event.

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